Solar Activity 2:
Model Results

Getting Started

Open the “Space Weather Explorer” (SWX) which has a link on the desktop. Use the File selector to navigate to the “Solar” directory. Open the “mas_cr2078.cdf” file. The simulation results in this file were generated using the MAS (“Magnetohydrodynamics around A Sphere”, insert links) model for Carrington Rotation (CR) 2078 near Solar Minimum in December of 2008.

- Click the “+” button to add a surface.
- Click the “tool” button to open the surface settings. The “R” component should be set with the “constant value” near “1”
- Choose the “B_r” variable to display on this surface. “B_r” is the radial component of the magnet which is very near that which is extrapolated from the solar magnetograms. Click “ok”.

The image should be very close to the synoptic map of the magnetogram synoptic map below and depicts the magnetic field near the surface of the Sun. For this model, the magnetograph synoptic map sets the inner boundary condition

Exploring the Solar Corona Solar Minimum

- In the “View” menu, click on “3D View” to see this image wrapped onto a sphere representing the solar surface magnetic field.
- You can rotate the image by using “click in drag” and zoom out using the mouse wheel.

1. **What general conclusions can you draw about the magnetic field at the surface of the sun during Solar Minimum? Is there a magnetic active region?**
2. **Draw what you think the solar magnetic field should look like in this case, and discuss it with your group.**
3. **What is the configuration of the field lines near the poles?**
4. **... near the active regions?**

You can choose some field lines by clicking on the solar surface in the original window.

- Start by clicking on field lines near the active region.

1. **What is the configuration of those lines? Do all the lines do the same thing?**

- Click on lines near the poles.

1. **What is the configuration fore these lines?How does this compare to you predictions above?**

2. **For field lines that begin and end on the surface of the sun, what can you say about the relative polarity of the foot points?**
3. **Approximately, what is the furthest extent that closed field lines extend out from the Sun?**

Clicking on the map provides seed points from which field lines are drawn. We can also import set of seed points from a text file. To explore the magnetic field more carefully, we can import a "regular" set of seed points.

- From the "View" menu, click on "Seed Points".
- Use "Shift - Click" to select all the seed points and click the "-" button to delete them. Alternatively you can click on "Remove all"
- Click the "Import" button and navigate to the "Solar" directory. The .csv files in this directory are text files with regularly spaced seed points. Choose "Global-1.5Rs.csv" to plot seed points starting at 1.5 solar radii. Click "ok" and hit the "Go" button on the 2D map. You may have to reopen the 3D view to see the field lines.
  - **What generalizations can you make about the origin of "open" and "closed" field lines?**
  - **Where do most of the field lines that reach the boundary originate from?**
  - **Where do most of the "closed field lines" originate from?**

Solar Maximum (Homework)

The example we will use for solar maximum is from CR 1965 which occurred during the last solar maximum, July of 2000.

- Use the "File" menu to navigate to the "mas_cr1965.cdf" file in the Solar directory.
- Clear the seed positions.
  - **What do you notice about the number and position of the magnetic active regions?**
  - **Draw what you think the solar magnetic field might look like for the CR.**
- Click on a few points on the map and explore the magnetic field structure.
  - **What conclusions can you draw about the structure of the closed field lines? Is it a regular structure?**
  - **What about open field lines? Where do they originate?**
- Confirm your conclusions by using the regular seed points at 1.5 Rs and 28 Rs

Conclusion

Open field lines that reach out into the heliosphere tend to originate from coronal holes where much of the solar wind originates.

- **What conclusions can you draw about the source of the solar wind at solar minimum and solar maximum? At what latitudes does the solar wind originate from on the Sun?**
- Return to the iSWA window.
  http://iswa.ccmc.gsfc.nasa.gov:8080/IswaSystemWebApp/index.jsp?i_1=71&l_1=419&t_1=269&w_1=451&h_1=373&i_2=5&l_2=662&t_2=633&w_2=395&h_2=427&i_3=4&l_3=218&t_3=644&w_3=417&h_3=428&i_4=137&l_4=15&t_4=253&w_4=388&h_4=400&i_5=139&l_5=907&t_5=261&w_5=399&h_5=409

- Choose a date near the Solar minimum case above near December of 2008. Notice the model output in the middle of the screen. This model is the (PSFF) model.
  - **Are the field lines shown here consistent with what you saw in the MAS model?**

Exploring the Structure of the Solar Wind

In this section we will look the solar wind structure using results from the "Enlil" (Enlil is the Sumarian God of the Wind)insert link here) model. We will look at results for the same Carrington Rotations that we looked at previously depicting conditions near solar minimum (CR 2078) and solar maximum (CR 1965). The simulations you will look at follow the solar wind evolution from approximately 0.15 AU (inside the orbit of Mercury) to 10 AU (just outside the orbit of Saturn).

Variation in the Plasma Parameters

- In SWX, use the "File" menu to navigate to "Solar" directory and open the file "CR2078-Enlil-10AU.cdf". This is the solar minimum case.
- Use the "+" button to add a cut plane window. A new tab will appear. Click on the "tool" icon for that tab adjust the parameters to add a constant "R" ("Component" menu) surface at the inner boundary (R = 0.144 AU) ("Constant Value") painted with the radial component of the solar wind velocity (Vr) ("Variable").
  - **What can you say about the organization of the solar wind on this inner boundary? Make note of the color scale.**
  - **Use the "tab tool" to change "Vr" to "Vlat" and "Vlon" to get the theta and phi components of the velicity. What do you notice about the structure and scale?**
  - **Use the "tab tool" to adjust the distance of the radial cut from the sun. Verify that your observations are consistent with at different distances from the Sun.**
  - **Does the overall solar wind speed change much with distance from the Sun?**

- Reset the radial cut plane to the inner boundary paint it with density ("N").
  - **What can you say about the organization of the solar wind on this inner boundary? How does this correlate with the velocity structure you saw before?**

- Add an equatorial cut plane ("Z" = 0) and paint that with density.
- To view both cuts at the same time, use the "3D" view from the view menu. Be sure to rotate the
  - **How does the density change with distance from the sun? Why does it change this way?**
- Change the variable painted to "N*r^2" which is the density multiplied by the square of the distance from the Sun.
  - **Discuss the structure you see now with your group. Why does plotting density this way help bring out the structure?**

Magnetic Field and the Solar Wind Flow

The magnetic field structure and the plasma velocity often cause some confusion among students. This section will have you explore both.

- At the top of the main SWX window is a drop down menu labeled “Streamlines”. It should be set to “B” so that it draws field lines. In the visualization window on the equatorial cut (“Z” cut plane”) click on some points. These will be seed points for field lines that appear. You should also see these in the “3D” window.
- Choose some points at the inner boundary image on the “Constant R” tab.
  - **With your group, describe the global structure of the magnetic field. Is it the same in the equatorial plane and at higher latitudes?**
  - **What direction do you expect the plasma to flow in?**
- Choose “View -> Seed Point” and clear all the seed points. In the main window select “V” in the “Streamline” menu. Click on points in the equatorial plane. These now show flow lines of the plasma.
  - **Are these flow lines what you expected? Discuss this with your group.**

Solar Wind at Solar Maximum (Homework)

- In SWX, use the “File” menu to navigate to “Solar” directory and open the file “CR1965-Enlil-10AU.cdf”. This is the solar maximum case. Follow the directions above and compare the results you get to the solar minimum case.
  - **What generalizations can you make about the structure and variation of the solar wind parameters at solar maximum?**
  - **How do these generalizations compare to those made at solar minimum?**